

**PROGNOSIS.** In the prognosis of pulmonary tuberculosis, fever is a most reliable index of the ultimate course of the disease. Fever that resists treatment always speaks for an unfavorable outcome. The height and duration of the fever affect the prognosis correspondingly. The absence of fever does not, as is often accepted, necessarily imply improvement. Progression of the disease in the absence of fever can be clinically demonstrated.

**CONCLUSIONS.** 1. There is a necessity for testing the accuracy of certified thermometers.

2. Normal temperature may vary within considerable limits.

3. The selective action of tuberculo toxin in pulmonary cases may directly affect other systems than the respiratory, and thus lead to error in diagnosis.

4. The temperature curve in pulmonary tuberculosis is protean in character, and may simulate that of many other diseases.

5. Fever is the cardinal symptom of incipient tuberculosis: its nature and persistence are of diagnostic import.

6. The persistence of fever bears a definite relation to prognosis.

The appended temperature charts are presented to illustrate types of fever in tuberculosis.

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## EXUDATES IN ARTIFICIAL PNEUMOTHORAX.

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WHEN one has had the experience of seeing a Lazarus rise from the dead, the incident will never be forgotten, and the procedure which enables this to be done will not be abandoned even though such dramatic successes are but few in comparison with the whole number of cases in which artificial pneumothorax is performed. This method is still in the experimental stage, and many more years' experience will be required to more truly indicate its limitations as well as the type of case in which it is likely to prove most successful. The mechanical conditions met with in advanced tuberculosis, as, for instance, adhesions, consistency of the lung to be compressed, thickness of cavity walls, metabolic reactions to compression, the state of the other lung, the effect upon complications, particularly those of tuberculous character, the alteration of circulation, position of the heart, and the effect of pressure upon

the digestive organs, compose a picture of great complexity with an endless variety of factors introduced into the problem presented by each and every case.

One thing seems certain, compression has come to stay, and the problem facing phthisiotherapists is the delimitation of the method—to use it for the greatest good of the greatest number of consumptives applying to us for help. The purpose of this paper is to assist in a measure toward the elucidation of the problem of the application of artificial pneumothorax.

We thought at first that our cases were too few to enable us to draw any conclusions from our own experience in clarifying the problems of this treatment, but we find upon studying the literature that the number of cases in which we have employed this method during the past three years will compare favorably with those of other clinicians. To date we have had fifty cases. In 50 per cent. it was impossible to obtain an efficient pneumothorax on account of the mechanical conditions encountered, such as adhesions, etc. In a small number, even though a certain degree of compression could be induced, it was not effective as regards compression of the essential lesion—the cavity, etc. There has been about the proportion of really successful cases that other observers have noted. From our experience we do not hesitate to draw two conclusions; one of them is that in certain of these cases in which a clinically effective degree of compression is impossible the procedure must be supplemented by surgery, and we think that the time will come shortly when a qualified surgeon will be necessary as an adjunct to the staff of every large institution for tuberculosis. The other conclusion is this: admitting, as we all do, that in something like 50 per cent. of the cases we cannot obtain an artificial pneumothorax on account of the mechanical conditions presenting, it seems to us very plain, indeed, that our efforts should be directed toward the anticipation of these extensive adhesions; in other words, that when a case presents the unqualified evidence of progression, especially in the presence of a relatively sound or arrested process in the good lung, that we should not wait until pneumothorax is forced upon us, but should perform this operation when it is not only mechanically possible, but when the organism is still capable of withstanding the effects of compression.

During the past year we have been trying to do this, and from the results already achieved we have little doubt that in a few years we will be able to prove, if it has not already been done, that the most successful pneumothorax cases will be those in which this method was applied in the comparatively early stages of advanced disease or in a progressive lesion not far advanced, when the conditions are of our own choosing and not relatively or wholly beyond our reach. It is all very well and gratifying to save an occasional far-advanced case by this method, but infinitely more useful to

prevent them in a larger proportion of cases from ever becoming far advanced, for under such conditions, as we all know, the method is grossly handicapped, not only by the 50 per cent. of instances in which it is no longer possible on account of the adhesions, but by the failure of the good or relatively good lung to withstand the effect of the pneumothorax, as well as by the unfavorable conditions presented by the body in far-advanced tuberculous disease, and also the possibility that complications, such as laryngeal or intestinal tuberculosis, the existence of which may have been previously unsuspected, may immediately become flamboyant in their manifestations upon the induction of a pneumothorax, though, as we all know, such complications, are as likely to be benefited as aroused to activity.

During the past year or two, as experience with this method has matured, we have heard more and more of the occurrence of exudates following pneumothorax; in fact, it is claimed by a consensus of opinion in Europe and America that in at least one-half of the cases in which pneumothorax is mechanically possible that ultimately an effusion will occur. It is but natural to suppose that the more extensive the involvement the more the pleura has been invaded by a tuberculous process; in other words the longer we wait the more likely we are to witness this phenomenon of effusion. An examination of the cases abroad definitely proves that this statement is true, and further substantiates our opinion that pneumothorax has other applications than are found in so-called hopeless cases. When we first read of the occurrence of these frequent effusions it was astonishing to us, for in but one of our 26 cases in which gas could be introduced effectively have we had a large effusion, and in but 4 an insignificant quantity of fluid, which in 1 was subsequently resorbed, and in 3 a small quantity still persists. Our physical examinations were controlled by fluoroscopic inspection. We asked ourselves, Is our experience unique? and if so, to what is it due? We communicated with the medical authorities at the United States Army General Hospital at Fort Bayard, New Mexico, and it proves that their experience has been as follows: of 19 cases in which artificial pneumothorax was induced there were 3 relatively large effusions, and in 3 cases there was a demonstrable quantity of fluid which did not increase or was subsequently resorbed. Webb, in Colorado Springs, reports "85 cases for pneumothorax in which we met with success more or less in the collapse of 63. Nine of these had moderately large effusions which we drew off part, and then they disappeared. I do not know how many we had with small effusions, as we did not Roentgen-ray them all." Shortle, of Albuquerque, New Mexico, reports "50 cases in which a satisfactory degree of compression was produced. Among these cases 9 developed an exudate, as shown by physical signs. No examinations of patients were made with

Roentgen-rays." We may take it then as probably true that on the high, dry plateau of the Rocky Mountains we do not have effusions in our pneumothorax cases with the frequency witnessed elsewhere, and when they do occur the tendency is to remain small and be reabsorbed. This phenomenon cannot be due to altitude, for von Muralt, at Davos, Switzerland, who has made a most exhaustive study of exudates, a report of which he presented last September before the eighth meeting of the Society of Sanatorium Physicians at Freiburg, states that at Davos they have the same percentage of exudates following artificial pneumothorax observed in other places. He observes without equivocation that general injury, such as cold, exertion, fatigue, intercurrent infections, account in a large measure for the occurrence of effusions. The reason why we do not apparently have quite so many effusions on the Rocky Mountain plateau may lie in the fact that we do not have colds and intercurrent infections among our tuberculous patients with anything like the frequency observed in less favorable climatic environments. It is only fair to observe, however, that in Europe this method has been employed much longer than in the United States, where it has only been used about three years to any extent, and that after longer experience we may see more effusions, though in the East the experience corresponds to that of Europe, even though they have employed pneumothorax a much shorter time.

Von Muralt, in common with most observers, thinks that the effusion in pneumothorax is directly parallel with the common exudative pleuritis; in other words, to use his exact language, "it is to be ascribed to a going over of the tuberculosis to the pleura." With this statement we do not wholly agree. The secretion of a fluid by the pleura is as natural a phenomenon as that of tears by the conjunctiva. If the tear duct is occluded the tears will overflow upon the cheeks. When the mechanism of the pleura is in perfect working order as to secretion and absorption an excess of fluid is never found; but we certainly know that as pneumothorax is protracted the absorption properties of the pleura become more and more impaired; that as time goes on refillings are required at longer and longer intervals, and in the presence of this impaired function on the part of the pleura it may be true that it will become less and less possible for it to take care of the excessive secretion. Exudate in the beginning may be a response to irritation, and the mechanical condition induced by pneumothorax, as well as a abnormal substance, such as nitrogen gas in contact with the pleura, certainly furnishes the factors of irritation. This theory will not apply to those exudates the result of pus infection, or of true tuberculosis of the pleura, in which tubercle bacilli are found in the exudate. However, these forms of exudate von Muralt states are in the minority, but we believe that this theory may be

the true explanation of the small serous and lymphocytic exudate. In contradiction to such a theory is the experience of Shortle, who has made it a practice to withdraw all exudates on their appearance in any quantity and replace with gas. It has been his observation after such a removal of exudate that it does not tend to return. Under our theory it would seem most likely to.

It has been proved that the choice of operation, whether Forlanini or Brauer, does not influence the occurrence of exudates. It also seems true that the more serious the case the more extensive the tuberculous pleuritis is or has been the more likely they are to occur. It is perhaps needless to say that the small and, as we think, mechanical effusions are of no importance and do not require treatment. In one of the four instances we have observed it was promptly resorbed, and in the three in which it persists there has been no tendency to increase. However, in the East and in Europe the large percentage of exudates observed becomes a factor of real importance in artificial pneumothorax. These exudates are said to gradually increase and more and more approximate pus in character, becoming first cloudy; later containing polymorphonuclear neutrophiles, and lastly tubercle bacilli. They finally lead to gross thickening of the pleura. It seems to be the common practice under such conditions and in the presence of pressure symptoms to remove a portion of the exudate and replace it with gas. All observers are practically a unit that washings and the injection of antiseptics are little worse than useless under these conditions.

We do not know when it first occurred to one of us, independent of artificial pneumothorax, in fact, years before we knew anything about this method, that nothing could be more favorable, especially in far-advanced tuberculosis, than an extensive effusion into the pleura. We are certain that independent of the practice of any other physician one of us (Bullock) distinctly conceived the idea that such effusions should never be disturbed except for pressure symptoms, and then only enough removed to relieve the circulation. Often after an effusion these patients would take on weight, present a normal temperature, slowing of the pulse, and a general feeling of well-being. The observation of a few of these cases in which effusion occurs naturally will prove to anyone that in such an exudate there is something, or a combination of things, which we suppose we can safely class under the generic term antibody or antibodies, which are vastly beneficial to the affected individual. There has never been a time during the past seventeen years when one of us has not had such a person under his observation, and we have a clear-cut conviction that as long as the fluid remains the individual is relatively safe, and that it is usually only upon its complete resorption that the tuberculosis resumes its course. As soon as Röhmer and Hamburger showed that the already tuberculous

animal could not be reinfected with tuberculosis, this, of course, being in line with Koch's original observation of the injection of tubercle bacilli into already tuberculous guinea-pigs, one of us (Bullock) felt safe in removing small portions of these natural effusions and injecting them into other and seriously ill consumptives. He did this several times, but to his surprise there was neither local nor general response. Why this fluid which partially protects the individual having it will not benefit others is difficult to understand. One reasonable explanation is, we think, that the quantity injected or possible of injection is too small or too infrequently employed, or both. The individual with the exudate, however, has a large reservoir of antibodies in the fluid upon which he can draw continuously.

Extensive exudates in artificial pneumothorax may produce, through vast pleural thickening, a marked shrinking of the pneumothorax, and, according to von Muralt and others, there occurs, in spite of refillings under high pressure, a retraction of the thorax with an expansion of the compressed lung before we are ready for any such functional mobility. Right here we must call in the surgeon and have him do a plastic operation, a Wehlm or some of its modifications, or better yet a Schede. We have never seen a pus infection of the pleura follow artificial pneumothorax. Such an accident must occur from infection from without by means of the needle or from perforation of the lung. All observers agree that they are very rare, and should be treated by thoracotomy, drainage, frequent washings, etc.

Von Muralt holds that on account of the great uniformity in the occurrence of pleural exudates in artificial pneumothorax that their cause must be wholly interior, and whatever the actual cause, whether a true tuberculous effusion (or, as we hold, the small mechanical effusion), he is undoubtedly right in attributing their causation to internal conditions and not to methods of procedure.

Von Muralt classifies the effusions as follows: (a) True serous or light sanguinolent exudates which remain small and show only a slight tendency to increase in quantity, and which generally disappear in the course of a few weeks or months. Of his 35 exudate cases 14 were in this category. Of our 5 exudates 4 were of this type (this is the character of exudate which we ascribe to mechanical causation). (b) Exudates which begin like (a) but have a greater inclination to increase and retain their character for a long time. (These also may be ascribed to a mechanical causation.) If, however, tubercle bacilli make their appearance in the effusion it is probable that a true tuberculous pleurisy has become superimposed upon the original effusion. As a rule, tubercle bacilli can only be demonstrated in these effusions by means of animal inoculations. Von Muralt has had 16 cases of this type which continued over a period of years, and in the later stages contained plentiful cell detritus. (c)

Virulent infections of the pleura with mixed organisms originating either through wound infection or rupture of the lung. Von Muralt has had 5 such cases. In one of our patients a natural was superimposed upon an artificial pneumothorax, with subsequent exudate, which examination proved to be sterile under the microscope. The fluid also proved negative when injected in a guinea-pig. Von Muralt makes it plain that the seriousness of the cases has a distinct influence upon the occurrence of an exudate. Of his 29 cases without exudate, 20 were moderately advanced, 7 very serious chronic, and 2 acute tuberculosis; while of his 35 exudate cases, 13 only belonged to the moderately serious class, 19 to the very serious chronic class, and 3 to the acute. With the first group exudates of the (b) type have been mostly observed by him. In his moderately serious cases exudate generally occurred later; in some cases not until a year after the first operation, and were usually small and serous. Von Muralt's experience corresponds to and may well be said to be a reflection of that of others. Therefore if it is so that the more serious the case the more likely the effusion is to occur it constitutes a most important reason for anticipating the use of pneumothorax and not waiting until the procedure is forced upon us. The microscopic examination of these exudates as well as animal experiments rarely shows anything, with the exception of the (c) type, but tubercle bacilli, if they are not wholly sterile, as is true of the (a) exudate.

According to von Muralt, Gratz, and Saugman it should be kept in mind that when a pneumothorax is present the pleura is unable to prevent a tuberculous focus from extending by means of the adhesion of the two membranes, parietal and enteral, but rather tuberculous foci are able to develop and spread on the surface of the pleura. The stimulation of such foci is in fact favored by tearing adhesions and stretching the pleura. In our opinion this accounts for some of the acute febrility manifested during the early stages of compression in some instances.

Saugman further states that we should remember that the pleura, through the steady contact with gas, is placed in a wholly unphysiological relation, which, as Kaufmann has demonstrated in dogs, produces an anatomical change of the serosa with a decreased ability of gas resorption, and as we would like to interject once more for the sake of emphasis, probably a decreased ability to absorb its own secretion. Von Muralt states that one has the right to accept the principle that the tuberculous pleura is particularly prone to exudative inflammation under these changed conditions. He also emphasizes that in addition to the causative factors already mentioned certain individual ones should be considered. In his 35 exudate cases, 11 had had marked pleuritis before the pneumothorax, and in these, in 6, exudate had occurred; to quote exactly, "doubtless, therefore, it is just the patients

which are individually disposed to exudates who take a pretty large share in pneumothorax exudates." Von Muralt, Forlanini, and Brauer all protest against the use of the term transudate as an explanation for the occurrence of fluid in pneumothorax. The reason for this seems to lie in the fact that the exudate does not appear in the beginning when the circulation changes are most marked. Faguoli, who has made a study of the character of exudates, has found them of not only high specific gravity, but with a high albumin content, which he states is good evidence in favor of their inflammatory origin.

Of course, on account of the extremely few exudates that have been observed in our work to date, it has been impossible for us to make any exhaustive study of their character; but in the 4 cases with small exudate that we have observed the exudate has been sterile even upon passage through animals. In the large exudate case the fluid is purulent and tubercle bacilli are present. For the same reason the insignificance of our exudate material, we are unable, from our own experience, to discuss the therapy of these exudates; notwithstanding which, as the result of a long and extended experience with natural exudates, we have very positive convictions regarding their treatment. From the point of view of treatment we can see no reason for differentiating natural effusions from those which follow artificial pneumothorax. We believe they should be handled the same, and that is, with certain qualifications to be explained later, let severely alone. If, however, upon gradual thickening of the pleura there is reexpansion of the compressed lung before it is clinically desirable and by refilling with nitrogen it becomes impossible to prevent this premature expansion, or, as in some instances, even upon withdrawal of a portion of the fluid more nitrogen cannot be introduced, then, providing the patient is in a position to withstand the operation, the desirability of a plastic should at once be considered. Under these conditions our conviction would be that a Schede should be performed rather than the tentative and less complete procedure of Wehlm. Von Muralt and others agree that in the presence of inflammatory symptoms and an exudate that positive pressures cause more inconvenience than the same pressure previous to the appearance of the exudate. Under these conditions, lowering the pressure to zero may at once reduce the fever. This is in line with the observation that all of us should have made that there are patients without exudates who must always have a zero or a bit of negative pressure in order to be free from fever. It is well at this juncture to state pointedly that every gas case is an individual matter, and that a theoretic degree of pneumothorax may practically prove undesirable. As one of us (Bullock) stated before the American Sanatorium Association in 1913, the least pressure that will accomplish the result clinically is the pressure to be maintained.



It now occurs to us that possibly one reason why we have seen so few effusions is because we have always used warmed nitrogen. The lack of this precaution may account in part at least not only for some of the effusions but also for the so-called pleural reflexes of which personally we have seen none. We have no doubt that von Muralt is correct in his observation that in small saculative, pocket-shaped, or indented pneumothorax, in which a compressing effect is only possible with high pressure, clots and progressive adhesions are easily formed. Several times we have been able to find a pocket which we could refill, using relatively high pressures, for a certain length of time, then, much to our surprise before we understood this phenomenon, we would never be able to find the pocket again. In such cases, if we are to accomplish anything with pneumothorax, high pressures and frequent refillings are essential.

It is advised in the presence of an exudate and inflammatory symptoms that the pressure should be kept neutral until the fever period is passed, high fever itself being treated by means of counter-irritation (the acetal cautery), the use of pyramidon, aspirin, etc. A small quantity of the fluid should be withdrawn for examination, and if pus and pyogenic organisms are found, energetic surgical measures should at once be instituted. If, however, the fever remains low in type we should employ all our supporting measures and patiently await an amelioration of the condition before resorting to radical surgical procedures. We will then have time to adequately study the situation, and if surgical intervention becomes necessary, know best just what sort of operation is likely to meet the situation. From von Muralt to Saugman and Brauer every observer is agreed that antiseptic injections into the exudate are worse than useless. In this connection von Muralt observes, in making his plea for the conservative management of exudates, that the removal of even a small portion of the exudate may exacerbate the symptoms. We have observed this phenomenon in natural effusions when we have been forced to remove a portion on account of pressure symptoms. In the absence of mixed infection in an exudate in which fever continues from one to two months or longer, von Muralt would not ascribe the fever to the exudate, but to a tuberculous focus either in the lungs or another organ. The same observation undoubtedly holds good in the absence of an exudate with the presence of a complete pneumothorax when fever persists.

All observers are agreed that in the presence of fever the removal of the exudate and cleansing of the pleural cavity—when the exudate has been sterile, or simply tuberculous and free from mixed infection—is more likely to accomplish harm than good. It should be remembered that it is in just such cases that with patience we are likely to witness the most happy sero-immunizing effect. To employ von Muralt's forceful observation, "whoever has been able to observe these remarkable beneficial changes will not do

things which do not bring any benefit anyway." In other words, to further follow von Muralt, the fact that an exudate is present does not indicate the use of surgery even if the test puncture looks ugly, grayish, and contains tubercle bacilli. He puts it very happily when he states "one must learn to consider the tuberculous pyopneumothorax as well as the dry pneumothorax as a pathological-physiological condition." When the temperature returns to normal in one of these exudate cases it is no longer necessary to keep the pressure low, and most observers are agreed that the individual indications can be followed as before the onset of the fever. It is as true of a large exudate as of a large pneumothorax that they may act unfavorably on the stomach, liver, and heart through the pressure exerted. Such conditions must be met either by lowering the pressure or partially removing the exudate. These large exudates are slowly resorbed, as is true in natural effusions, and the end result is the same in both instances, an enormous pleural thickening, which helps to permanently maintain the lung in a state of physiological rest. Nearly everyone who has to do with a large number of consumptives has observed this termination in natural effusions, and some of the most brilliant results in far-advanced cases we have ever seen have fallen in this category.

True empyemas with marked clinical manifestations are amenable only to plastic operations. Von Muralt thinks, however, that if they are small in quantity that large antiseptic injections, for instance, 20 to 30 c.c. electrargol in repeated doses, if necessary, are often sufficient to arrest the process. According to him this is particularly true of pneumococci infections. In his opinion, however, if improvement does not soon follow this measure, the exudates should be reduced through puncture; but the plastic operation for the reduction of the pleural cavity should not be done until the abscess has been drained by a thoracotomy, thus lessening the chance of infection of a large plastic wound. Forlanini states that the imposition of a natural pneumothorax upon an artificial one is an absolutely fatal catastrophe. We have had one such case in which all the classical symptoms of rupture of the lung were present, which were subsequently followed by an effusion of clear sterile serum, and in which instance up to the present time (eleven weeks after the rupture) the patient is either holding her own or improving a little.

A phenomenon which occurs in pneumothorax of very great interest, for it is still unaccounted for, is the preliminary marked loss of weight which occurs in many of these cases no matter how completely the clinical symptoms are relieved. We have endeavored to account for it specifically, but so far have had to content ourselves with the generalized explanation of altered metabolism and circulation following the unphysiological relations of artificial pneumothorax. It has been observed, however, that should effusion

occur the loss of weight stops promptly and the patient begins gaining in weight.

In this country it is too early to permit of adequate discussion of end-results. In Europe they are just beginning to do so, but it seems reasonable to expect that in time our end-results will approximate theirs. This will prove notably true providing the measure is reserved in the future, as it has been in the past, in large measure, for otherwise hopeless cases. If, however, as we advocate, the method is applied in all suitable cases that are progressive in type the story may read more happily. There is one point to be borne in mind which was especially marked in the experience of one of us in the earlier use of pneumothorax, and which we have not seen mentioned by other workers. It is this: It requires relatively a higher pressure and a larger pneumothorax to relieve the clinical manifestations in a lesion confined to one lobe than it does in more extensive disease of the lung. Under these conditions we more often observe the phenomenon which European operators designate as "puffing up of the mediastinum." In several instances in which we have performed this procedure in one-lobe cases we have had the physical signs and sounds of pneumothorax impinge upon the sound lung as much as three inches from only a slight positive pressure. On the reduction of such a pressure the former signs and sounds returned to the area in question. We have never seen any harm come from such a dislocation of the mediastinum.

For many years the workers in the Rocky Mountain plateau have tried to impress upon their Eastern confrères that under our climatic conditions the picture of tuberculosis is altered and ameliorated as compared with the manifestations of the disease in many other localities; that patients do not have night sweats; that hemorrhages are less often observed; that fever is less often in evidence, and patients apparently acquire sooner, and in greater number of cases, a toxic immunity; that the circulation is improved; that the red blood cells are increased in number; that the percentage of lymphocytes tends to increase; that tubercle bacilli disappear sooner from the sputum; that the lesions are drier; and, in fact, that we get better results. We would furthermore like to impress upon our Eastern confrères that we apparently do not have exudates, or such serious exudates, with the same frequency as they do in the East and many other localities.